# Archive Media

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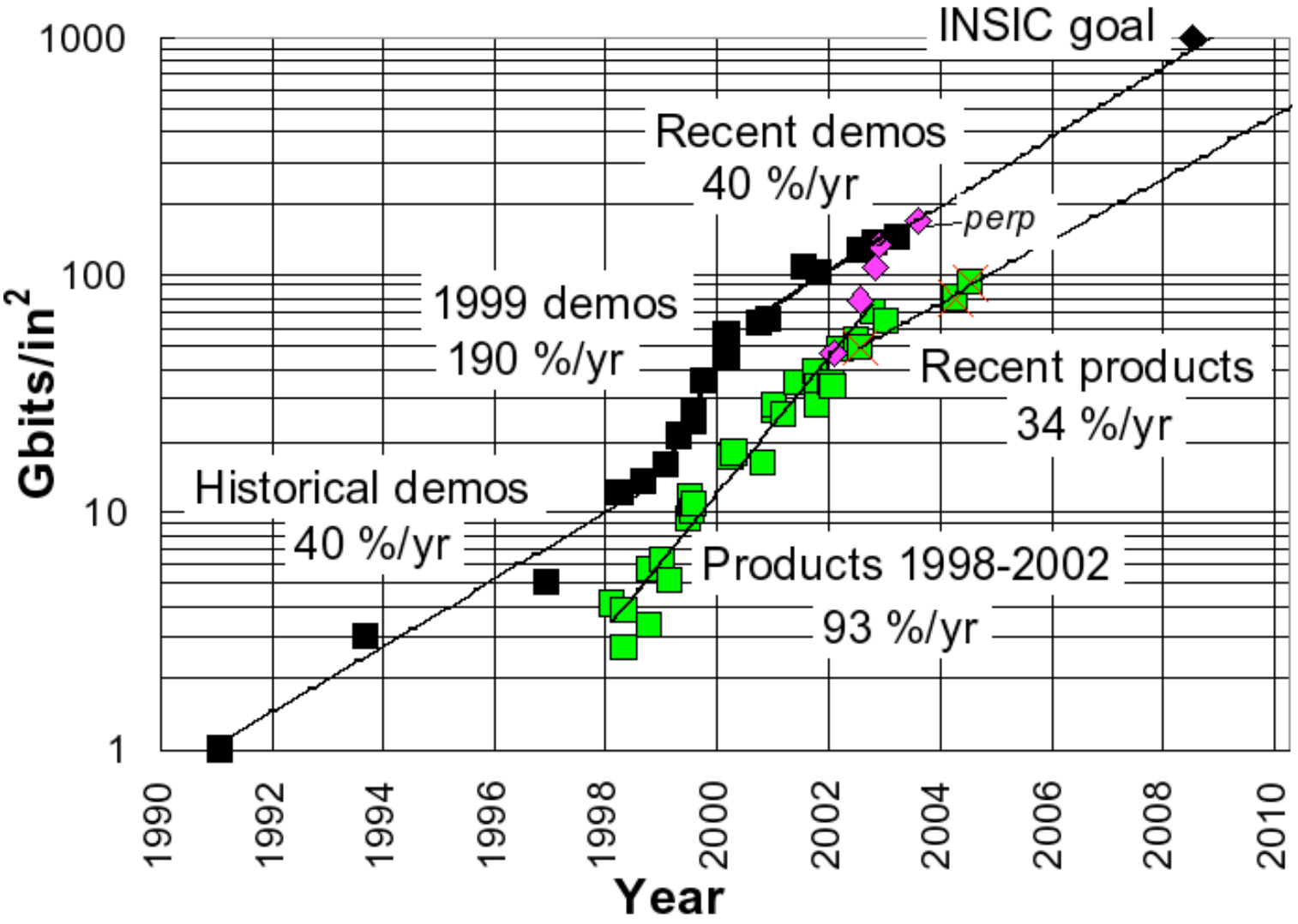
# Agenda

- Tape
- Holographic
- Roadmap Comparison
- Conclusion

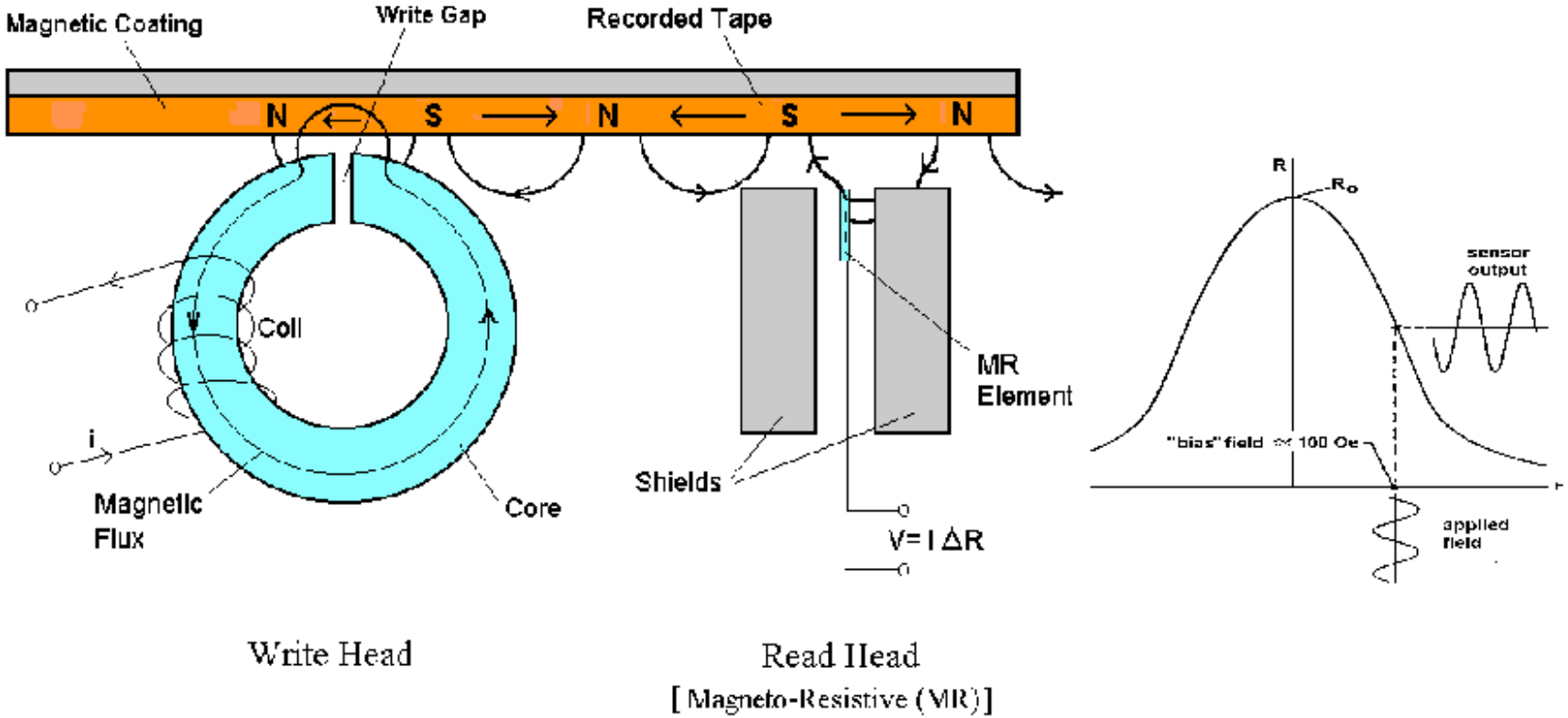
# Tape

- “Boldly going where we’ve gone before”
  - Richard Dee, Sun Fellow
- Scaling still works, no new technology needed (yet...)
- Disk experiencing Superparamagnetic challenge (again...)

# Disk Density Growth



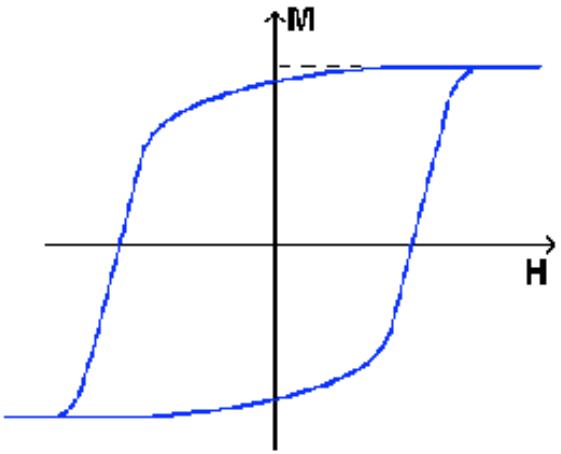
# Tape Technology Summary

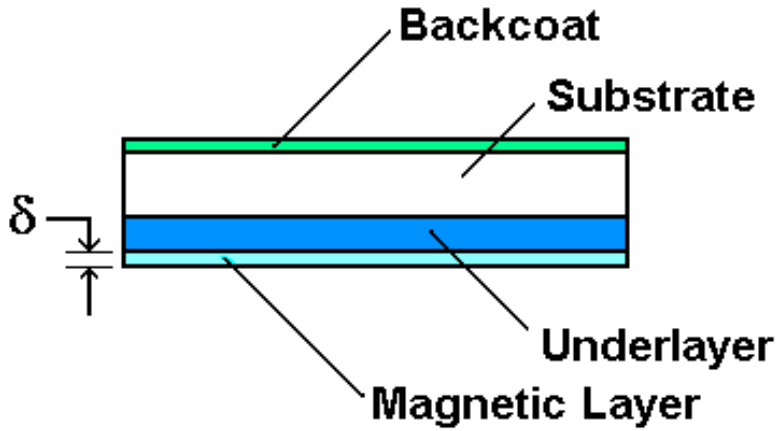


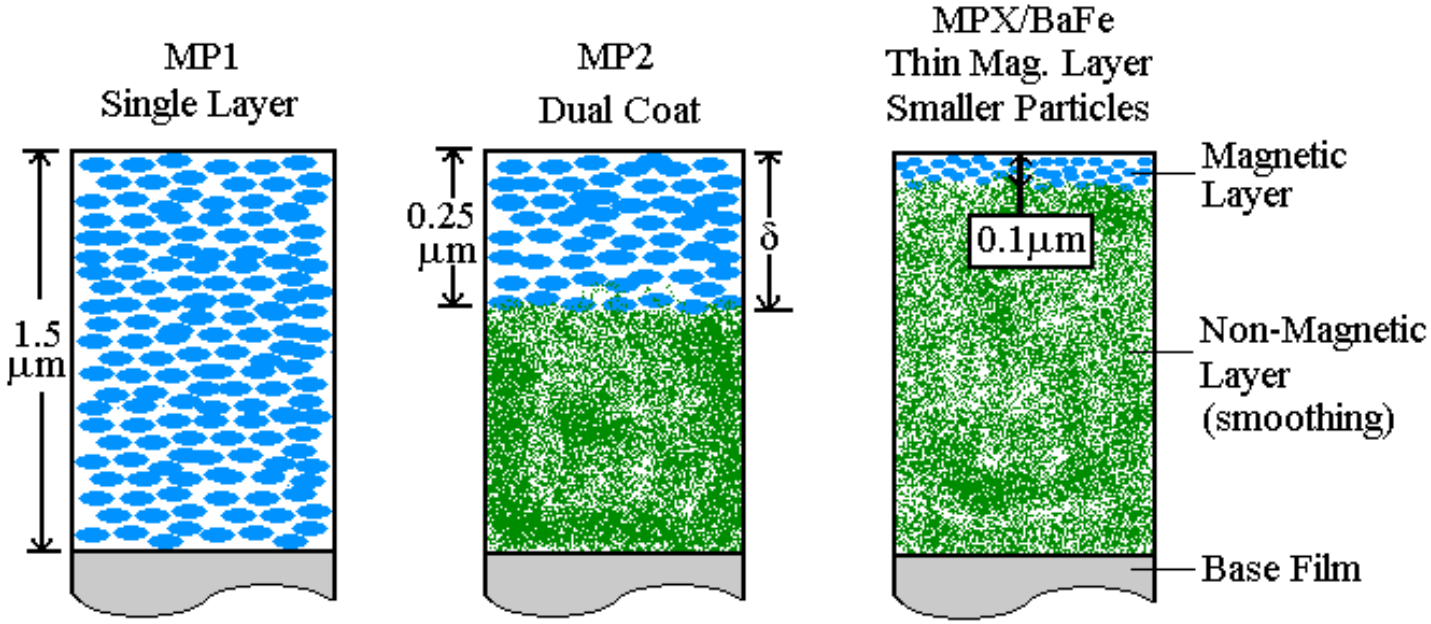

Write Head

Read Head
[ Magneto-Resistive (MR) ]

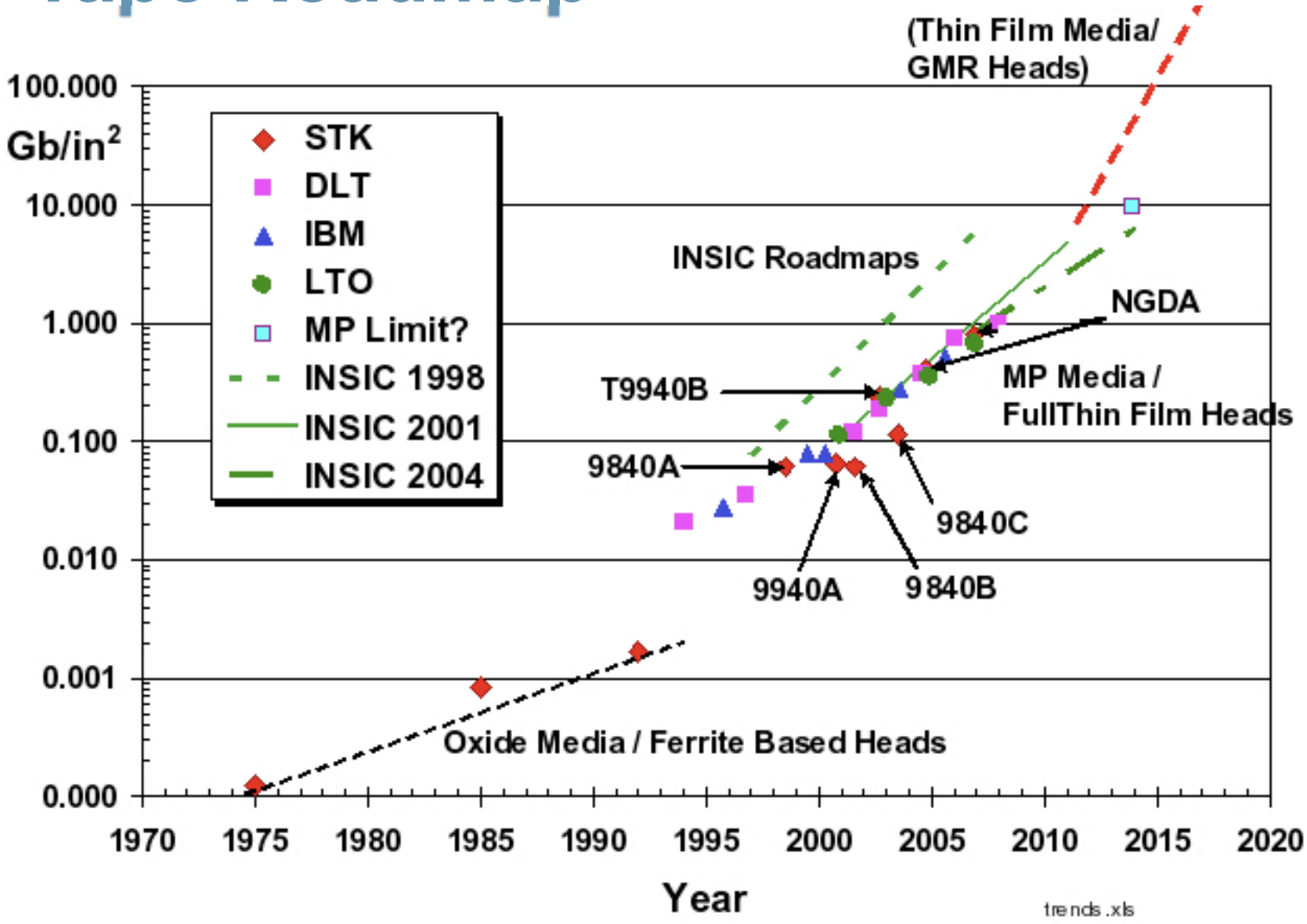
# Tape Media


M
H


Backcoat
Substrate
δ
Underlayer
Magnetic Layer


MP1
Single Layer
1.5 µm
MP2
Dual Coat
0.25 µm
δ
MPX/BaFe
Thin Mag. Layer
Smaller Particles
0.1µm
Magnetic Layer
Non-Magnetic Layer (smoothing)
Base Film

# Tape Roadmap



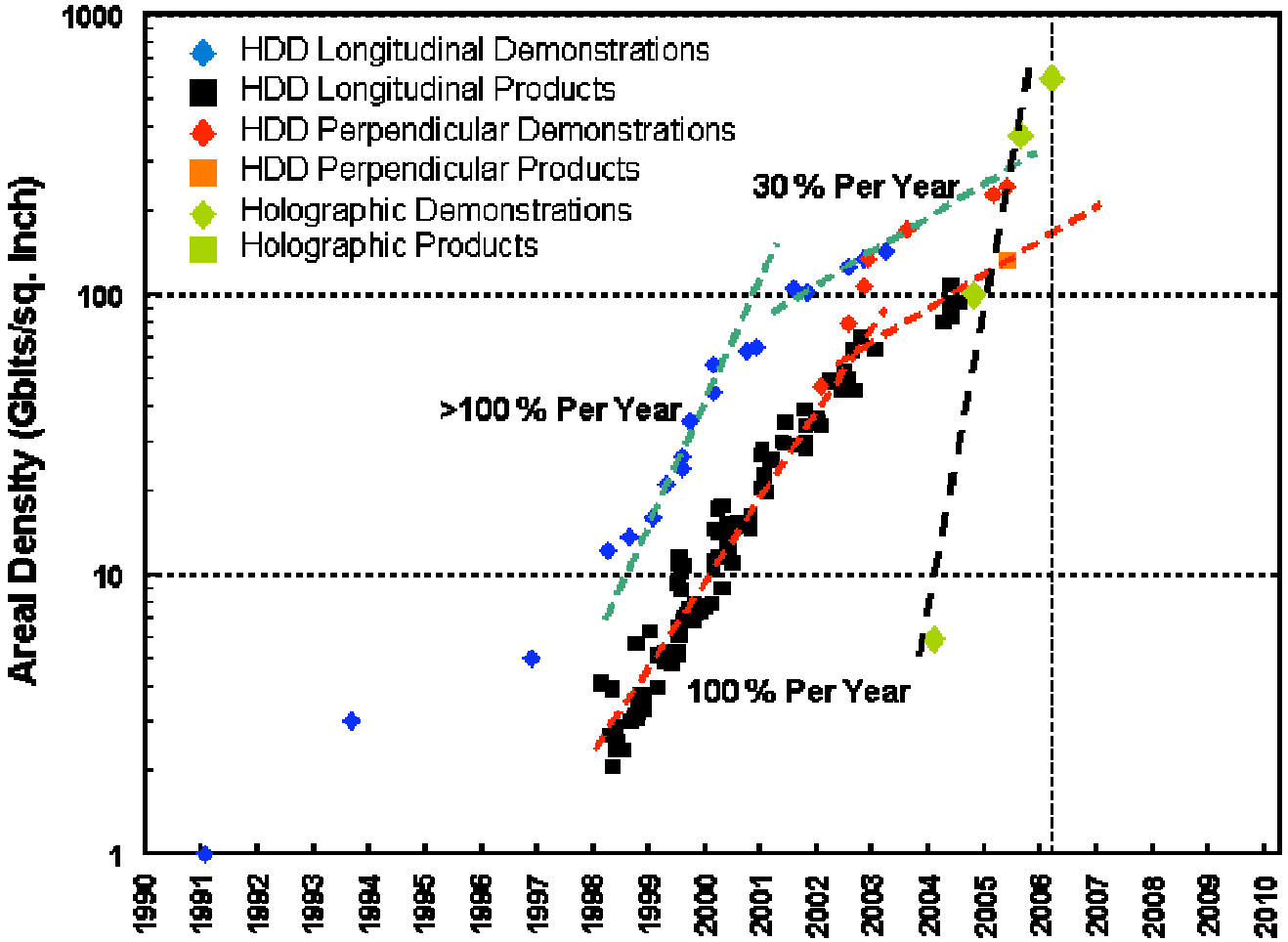
# Industry Roadmap

| Year | 2005 | 2007 | 2009 | 2011 | 2013 | 2015 |
|---|---|---|---|---|---|---|
| Capacity (TB) | 0.5 | 1.0 | 2.0 | 4.0 | 8.0 | 16.0 |
| Data Rate (MB/sec) | 75 | 120 | 200 | 320 | 500 | 800 |
| Areal Density (Gbits/in$^2$) | 0.44 | 0.86 | 1.53 | 2.73 | 5.06 | 10.10 |

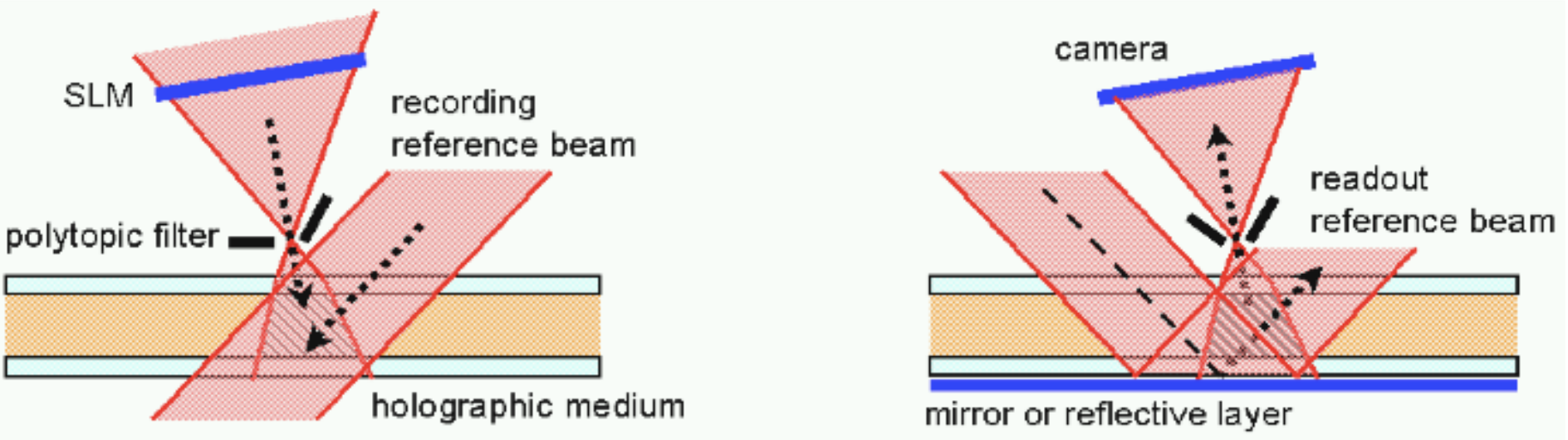
# Why Holography?

- Functional potential
  - Magnetic disk storage densities +
  - High capacity (TB+/disk),
  - High data rate (100+ MB/s)
  - Random access (“disk-like”)
  - Long archival lifetimes -- 50+ years
  - Removable, write-once media, with re-writable options
- Unique capabilities
  - Ultra fast search (Gb/ns!?)
  - Replication

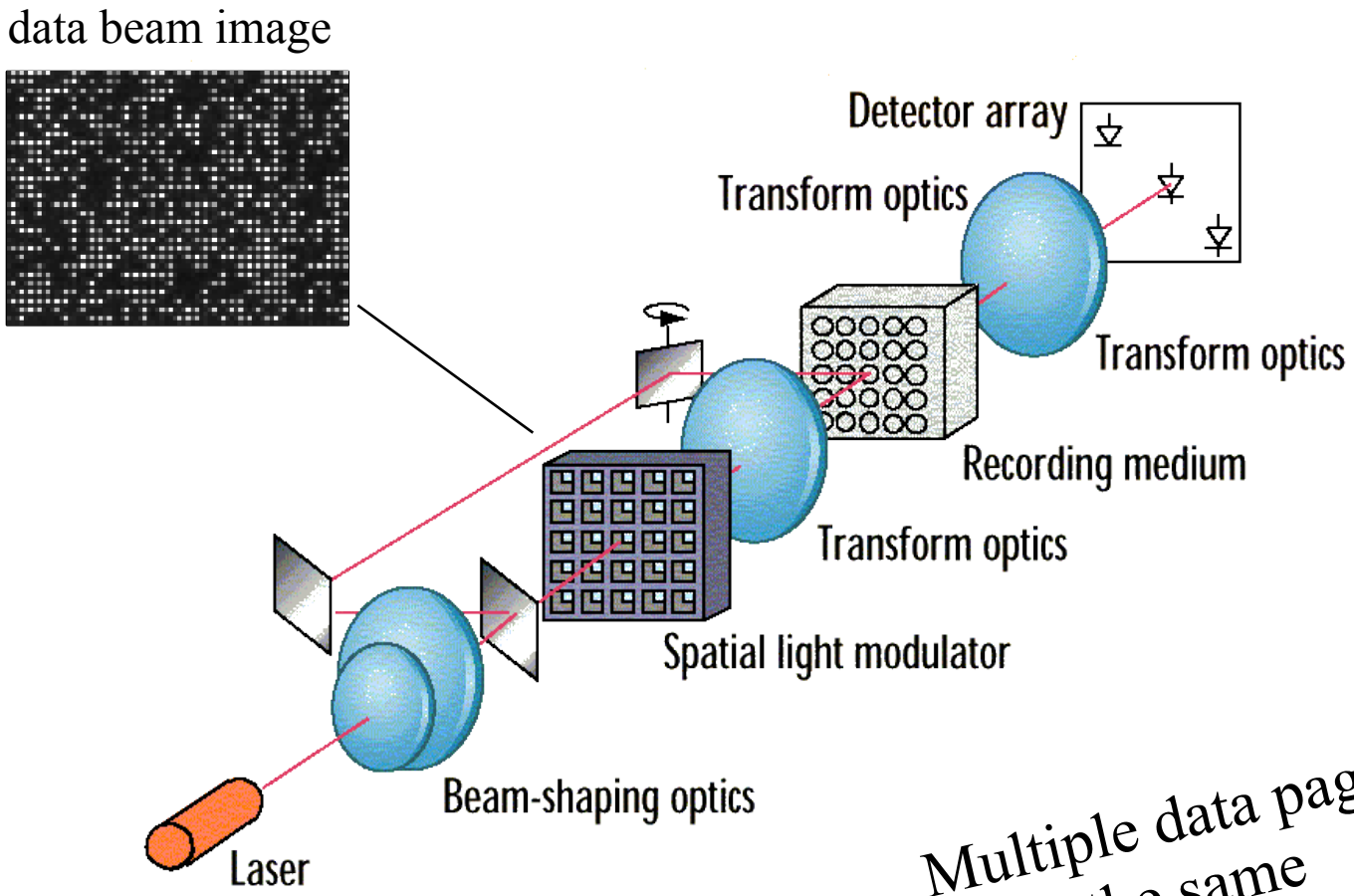
# Holographic Roadmap



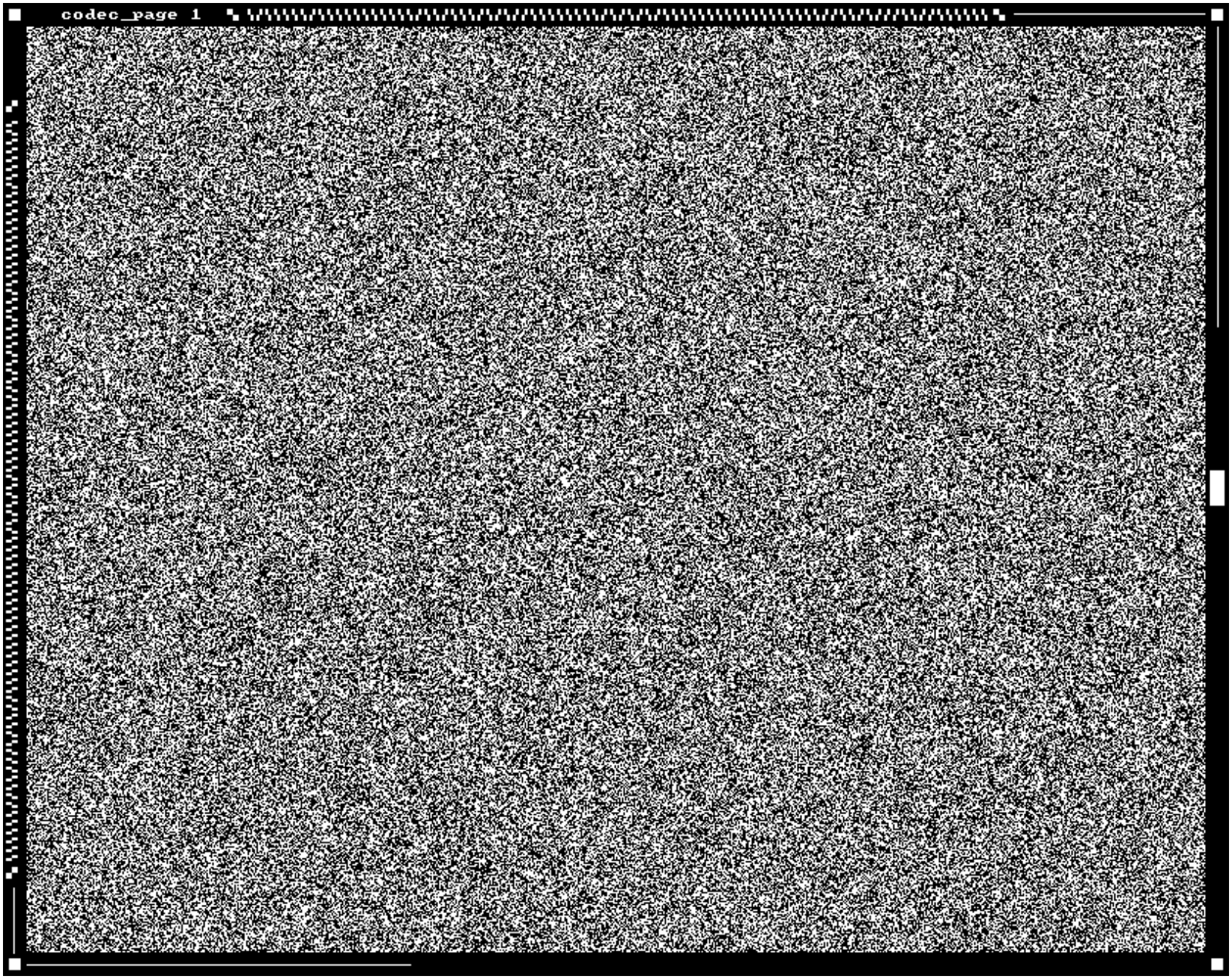
# Recording method



# Holographic Storage Fundamentals



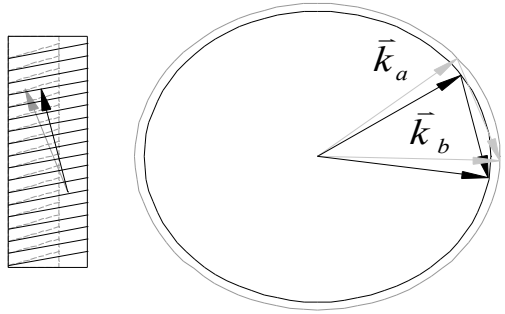

Multiple data pages share the same media space

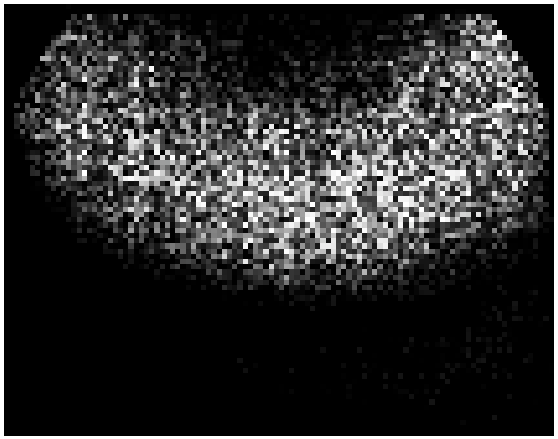

codec_page 1

| | 2005 | 2007 | 2008 | 2009 + |
|---|---|---|---|---|
| **Specs** | 350 Gb/in2<br>160 Mbits/s | 1000 Gb/in2<br>640 Mbits/s | 1600 Gb/in2<br>960 Mbits/s | 2000+ Gb/in2<br>960+ Mbits/s |
| **# of pages per book** | 340 | 370 | 753 | 941 |
| **Reference Beam Sweep (degrees)** | 20 | 25 | 30 | 37.5 |
| **Hologram pitch (q, r) (mm)** | 0.82, 0.7 | 0.82, 0.48 | 0.82, 0.48 | < 0.82, 0.48 |
| **NA of object beam** | 0.65 | 0.65 | 0.65 | 0.65 |
| **Bragg Null** | 2nd | 2nd | 1st | 1st |
| **SLM Pixels** | 1280x1024 | 1200x1200 | 1200x1200 | 1200x1200 |
| **Camera Pixels (4/3 OS)** | 1280x1024 | 1696x1710 | 1696x1710 | 1696x1710 |
| **Camera sensitivity (Counts/(J/m^2)** | 176,000 | 350,000 | 700,000 | 1,000,000+ |
| **Laser power (mW)** | 50 | 70 | 100 | 100 |
| **Wavelength (nm)** | 407 | 407 | 407 | 407 |
| **Material Thickness (mm)** | 1.5 | 1.5 | 1.5 | 1.5 |
| **Media Sensitivity dn/J** | $5x10^{-6}$ | $7x10^{-6}$ | $10^{-5}$ | $>10^{-5}$ |
| **M# of media @1.5mm** | 33.3 | 90 | 135 | 135+ |

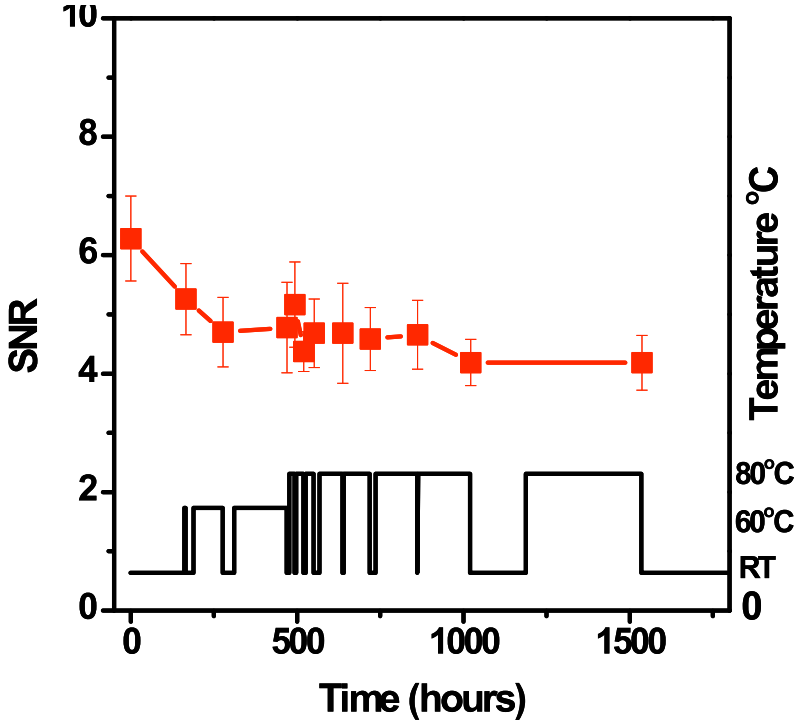
# Temperature Effects

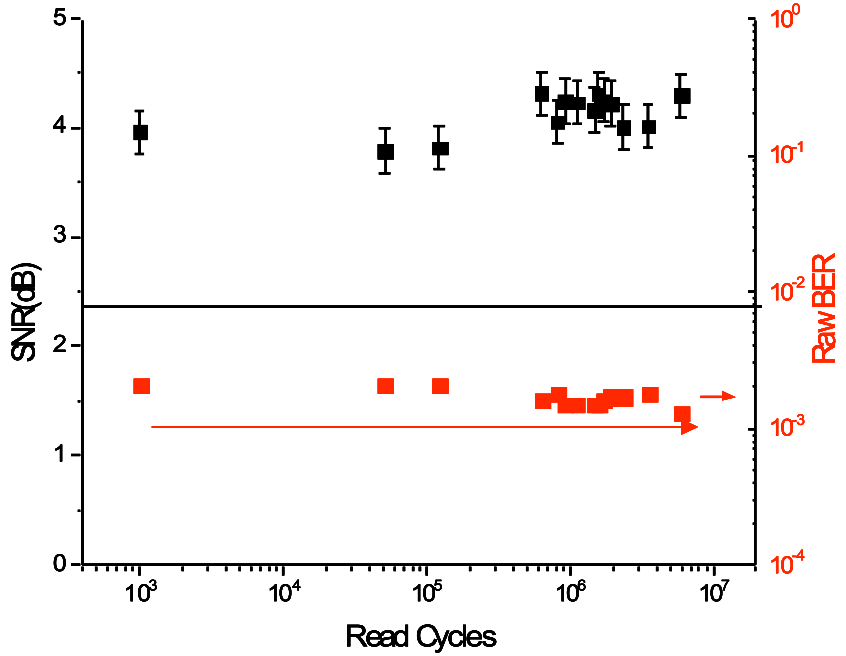
- K-sphere formulation showing the effects of temperature changes on grating vectors.
- The effect of temperature on a stored data page causes only narrow band of the manifold of grating vectors to Bragg match.



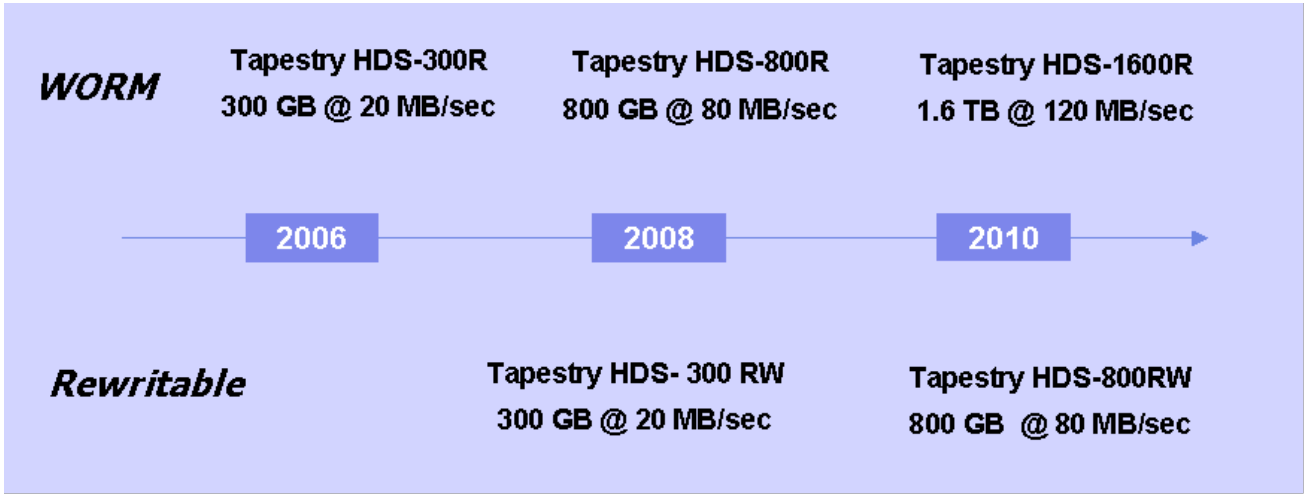
# Archival Stability of the Two-Chemistry Materials



# Roadmap Comparison

- Holographic




- Tape

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# Conclusion

- Tape
  - Well understood, proven track record
    - Existing products
  - Similar cubic density
- Holographic
  - Promising (again)
  - Faster seek time
    - Load time similar for removable media (without seek)
  - Potentially lower cost media
  - Some life testing has occurred